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Abstract* — *This study aimed at optimizing a pseudo-Continuous Arterial Spin Labeling (pCASL) approach to quantify hepatic perfusion in MRI. Six volunteers were examined using a 3T Siemens scanner, pCASL sequences with 4 and 20 repetitions were acquired in a plane orthogonal to portal vein with a post label delay (PLD) of 600 ms. For two subjects, four additional PLD (varying from 1000 to 1600 ms) were tested. Data were processed using specific software, which computes parametric maps of hepatic perfusion (HP). Global results show a more robust HP estimation when using 20 repetitions. The five PLD values provided hepatic perfusion weighted differently by the hepatic artery and the portal vein blood flows. This strategy could be used to estimate separately these two components.

Index terms - Image Processing, MRI

I. INTRODUCTION

The development of new antiangiogenic treatments for patients with cancer requires a specific monitoring. In case of hepatic lesions, the follow-up of hepatic perfusion, currently done using contrast enhanced dynamic MRI, is crucial but alternative methods without contrast agents are desirable, especially for new hybrid PET-MRI scanners. If arterial spin labeling (ASL) and pseudo-continuous arterial spin labeling (pCASL) have been widely developed for assessing brain perfusion [1, 2], only few studies have proposed ASL for estimating liver perfusion [3, 4]. The purpose of this pilot study was to assess the feasibility of pCASL for measuring the hepatic perfusion in healthy volunteers.

II. MATERIALS AND METHODS

II.1. Acquisition protocol

Six healthy volunteers were examined using a 3T scanner (Siemens TIM TRIO) and an abdominal coil. A localizer sequence and anatomical sequence (MPRAGE with 2x2x5mm^3 resolution) were first acquired to define the labeling plane of the pCASL scan as orthogonal to the portal vein. The sequence parameters were: 2D echo-planar imaging (EPI) with a respiration trigger; field of view: 288 mm x 90.6%; 4.5x4.5x8 mm^3 resolution (six or seven slices); distance factor: 10%; flip angle: 90°; fat suppression with fat sat; PAT mode GRAPPA; EPI factor 58; bandwith 3256 Hz/pixel; echo spacing 0.39 ms. The distance between the imaging and tagging planes was set at 50 mm. Figure 1 illustrates a pair of labeled and control images.

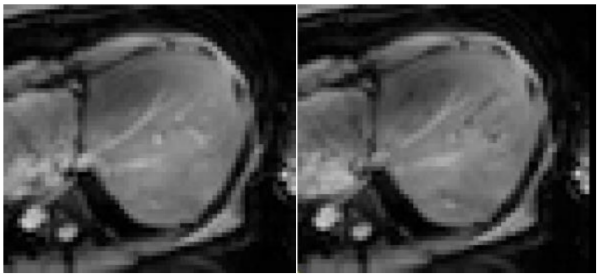

Figure 1: Two consecutive labeled and control images acquired with a post-label delay of 600 ms.

All sessions included a post label delay (PLD) set at 600 ms. Two series of pCASL acquisitions allowed test of 4 and 20 repetitions. For two subjects, four additional PLD (1000, 1200, 1400, and 1600 ms) were tested, using 20 repetitions.

II.2. Data processing

Data were analyzed using in-house software. The mean ASL difference signal was computed and converted to maps of hepatic perfusion (HP) using the ASL kinetic model described in [5]. The mean liver perfusion was computed inside a volume of interest encompassing the hepatic parenchyma. Voxels with flow values exceeding 500 ml/100g/min were excluded to eliminate intravascular signals from hepatic blood vessels.

III. RESULTS

III.1. Influence of the number of repetitions

Mean HP values and standard deviations are reported in Table 1 for the six examinations acquired at a PLD of 600

ms. They ranged from 56 to 119 ml/100g/min for 4 repetitions, and from 71 to 114 ml/100g/min for 20 repetitions. Using 20 repetitions provides more homogeneous values of HP and systematically reduces its standard deviation.

Subject	HP (4 repetitions) (ml/100g/min)	HP (20 repetitions) (ml/100g/min)
S1	95±133	95±130
S2	119±177	84±129
S3	57±150	71±127
S4	115±172	114±130
S5	56±188	84±123
S6	72±154	79±117

Table 1: Mean hepatic perfusion and standard deviations estimated from pCASL acquisitions obtained with 4 and 20 repetitions and a post label delay of 600 ms.

II.2. **Influence of the post label delay**

Table 2 indicates the mean HP values for the two subjects acquired with different PLD values and 20 repetitions.

PLD (ms)	HP for S5 (ml/100g/min)	HP for S6 (ml/100g/min)
600	84±123	79±117
1000	83±137	86±124
1200	145±170	95±135
1400	93±173	125±126
1600	88±165	108±138

Table 2: Mean hepatic perfusion and standard deviations estimated from pCASL acquisitions obtained with increasing values of post-label delays.

Figure 2 shows two hepatic perfusion maps computed on the same subject and acquired respectively with a PLD of 600 ms, and a PLD of 1200 ms, using 20 repetitions.

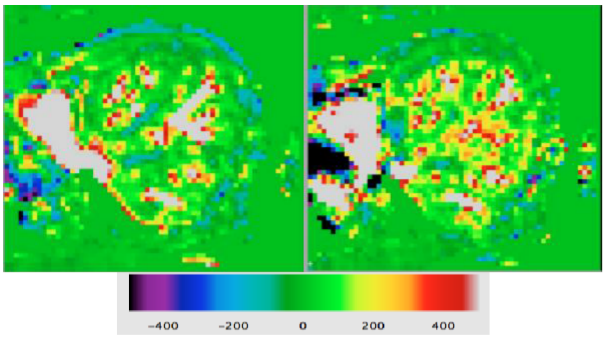

Figure 2: Quantitative perfusion maps (expressed in ml/100g/min) obtained for PLD=600 ms (on the left side) and PLD=1200 ms (on the right side).

We systematically observed high values of perfusion inside portal vessels for PLD values of 600 ms. Those regions with values higher than 500 ml/100g/min were excluded for the computation of the mean hepatic perfusion. This effect disappeared for higher values of PLD, while the global hepatic perfusion increased.

IV. DISCUSSION – CONCLUSION

Hepatic perfusion values are within known physiological values [3, 4]. Of course, the number of repetitions (4 or 20) is crucial and needs to be optimized to have the most accurate HP evaluation, while keeping the acquisition in reasonable durations for patients. The variability in results is due to multiple factors: a high vascularization of the liver, difficulties to have a correct respiratory triggering and to compensate for residual motion, noise issues. Mean HP obtained with PLD values higher than 600 ms tend to increase up to 1200 ms or 1400 ms before decreasing. This result suggests that the value of PLD could provide HP values weighted by the hepatic artery blood flow (low values of PLD) or the portal vein blood flow (high values of PLD). Indeed, the tagging plane goes across both the hepatic artery and portal vein and the hepatic artery blood flow is about two times faster than the portal vein blood flow.

Pseudo-continuous arterial spin labeling is a non-invasive MRI sequence, which could be used to evaluate and quantify liver perfusion. Our pilot study shows the influence of the number of repetitions. Furthermore, using different post label delays could help to distinguish perfusion between hepatic artery and portal vein. These preliminary results are of prime interest for the follow-up of an antiangiogenic treatment on hepatic tumors, showing generally an increased hepatic arterial perfusion.

ACKNOWLEDGMENTS

We are grateful to Carollyn Hurst and André Cyr from the CRIUGM for their involvement in this study. This research was supported by grant RBIQ 5886.

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